1126. After the macro has been assigned, the task **1120** is performed. If the macro is a finite job, the task is either complete at **1122** or incremented at **1124**. If the macro is a loop, the task **1120** is performed continuously until there is an operator interrupt at **1126**.

[0152] The operator could alter the machine movement during that portion of the macro ("delta control"), and then release manual control of the operation for continuation with the original macro control. Such "delta" control could be one-time or recorded by the controller **1016** for repetition. The operator on a trenching job, for example, could merely reposition the equipment, while allowing automatic material extraction and dumping functions under computer control using such a macro. The process ends at **1128**.

[0153] FIG. **25** shows a road (motor) grader **1204** equipped with a GNSS guidance system **1202** comprising another alternative embodiment of the present invention. Like the excavator **1004** discussed above, three antennas **1212***a,b,c* are placed on the body of the grader **1204** and connected to a GNSS receiver **1214**, which connects to a CPU **1216** containing a storage device **1218**. The grader **1204** includes a grader blade **1206** mounting blade antennas **1213***a,b*. The grader blade **1206** can be raised, lowered and tilted by a pair of actuators **1208** connected to the body of the grader **1204** and controlled by the system **1202**.

[0154] The grader blade **1206** is adapted for vertical Z-axis movement and yaw rotation about the Z-axis. The blade **1206** can also be tilted by rotating it about a generally transverse Y axis, and can be adapted for positioning through six degrees of freedom. Thus, in performing guidance tasks similar to the excavator mentioned above, the guidance system CPU **1216** is adapted for controlling optimal positioning of the guidance blade **1206**, guiding the grader **1204** and performing all necessary machine control and guidance functions for a predetermined task, such as grading a road, a paved area or other structure. Alternatively, relative positioning sensors, such as those described above, could be provided for the blade **1206**.

[0155] While the description has been made with reference to exemplary embodiments, it will be understood by those of ordinary skill in the pertinent art that various changes may be made and equivalents may be substituted for the elements thereof without departing from the scope of the disclosure. In addition, numerous modifications may be made to adapt the teachings of the disclosure to a particular object or situation without departing from the essential scope thereof Therefore, it is intended that the claims not be limited to the particular embodiments disclosed as the currently preferred best modes contemplated for carrying out the teachings herein, but that the claims shall cover all embodiments falling within the true scope and spirit of the disclosure.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. A GNSS guidance and control method for earth-moving equipment including a vehicle movably mounting a ground-engaging tool at an articulated vehicle-tool connection, which method comprises the steps of:

providing a grading plan including design elevations;

equipping the vehicle with a GNSS system including multiple GNSS antennas, a GNSS receiver connected to the antennas and a programmable controller connected to the GNSS receiver;

programming the controller to compute GNSS-defined positions of said antennas using GNSS ranging information;

determining with the GNSS-defined antenna positions vehicle position and attitude in three dimensions (3-D);

providing a sensor at the vehicle-tool articulated connection;

outputting from said sensor a signal corresponding to a position of said vehicle-tool connection; and

guiding said vehicle and the ground-engaging tool with the controller based on said vehicle position and attitude, said vehicle-tool connection position and a task performed by said vehicle and tool.

2. The method according to claim **1**, which includes additional steps of:

preprogramming said controller with GNSS-defined task information; and

comparing with said controller said task information and a ground-engaging tool position.

3. The method according to claim **1**, which includes the additional steps of:

establishing said design elevation by creating a terrain map prior to performing any work; and

designating areas need of cut or filled depending on said design elevation.

4. The method according to claim **1**, which includes the additional step of:

defining said design elevation in relative coordinates based on a benchmark placed on the site at the desired design elevation.

5. The method according to claim **4**, which includes the additional step of:

converting said relative coordinates to absolute coordinates using an absolute position of a benchmark reference point.

6. The method according to claim **1**, which includes the additional steps of:

providing inertial gyro and accelerometer movement sensors on said equipment;

providing output corresponding to movement of said equipment from said movement sensors;

inputting said movement sensor output to said controller; and

controlling said equipment in response to output from said movement sensors.

7. The method according to claim **6**, which includes additional step:

providing multiple arm element sensors each connected to a respective implement arm element of said vehicle;

determining a position and an attitude of each arm element with a respective arm element sensor;

providing output corresponding to a respective arm element position and attitude from each said arm element sensor;

inputting said arm element sensor output to said controller; and

controlling said equipment in response to output from said arm element sensors.

8. The method according to claim **1**, which includes the additional step of:

detecting directions of movement with the GNSS, including roll, pitch and slew rotation about the X, Y and Z axes respectively.

9. The method according to claim **1**, which includes the additional step of:

providing additional GNSS antennas on said implement arm elements;

providing GNSS-based location data for said arm elements to said controller; and